Patent claims

1. A method of allocating transmission parameters to individual carriers of a multicarrier communication system for each coded and modulated symbol to be transmitted, the method determining an optimum overall value of a first of said transmission parameters while meeting predetermined constraints for an overall value of a second parameter, the carriers being adaptively modulated, characterised in that, for a system providing also for an adaptive coding, the method comprises the steps of:

a) determining, for all carriers, a respective plurality of transmission modes characterised each by a specific combination of a modulation format and a coding scheme and consequently by a specific combination of values of said first and second parameters;

b) determining, for all carriers, transition costs associated with a transition from one mode to a lower one characterised by lower values of said parameters, a transition cost being representative of a decrease in the first parameter as a function of the decrease in the second parameter;

c) allotting to each carrier a respective first transmission mode associated with a maximum value of said transmission parameters;

d) evaluating the overall value of said second parameter;

e) if the overall value of the second parameter meets the constraints, using said respective first transmission mode for all carriers;

f) if the overall value of the second parameter does not meet the constraints, changing the mode allotted to one of the carriers to a lower mode, the carrier and the target mode selected for such change being those for which said change results in a minimum transition cost;

g) evaluating the overall second parameter after the mode change at step d);

h) possibly iterating steps f) and g) until the second parameter meets the constraints.

2. A method as claimed in claim 1, characterised in that the carriers are allotted the values of the first and second parameters associated to the modes resulting at the end of the iterations.

3. A method as claimed in claim 2, characterised in that the carriers are allotted the values of the first and second parameters associated to the modes resulting at the end of

the iterations if the second parameter meets the constraints and has an overall value equal to a preset value.

4. A method as claimed in claim 3, characterised in that, if at the end of the iterations the second parameter meets the constraints and has an overall value better than a preset value, the method comprises the further steps of:

i) undoing the last mode change;

j) checking whether in any of the carriers there are mode changes associated with a higher transition costs but leading to a respective target mode associated with a better value of the first parameter;

k) in the affirmative, returning to step f);

l) in the negative, using the transmission modes determined at step h).

5. A method as claimed in any preceding claim, characterised in that the cost function of the mode transitions are determined as the product of a carrier-independent normalised cost function, calculated as the ratio between the variation in the first parameter occurring because of said transition and a corresponding variation of the signal-to-noise ratio required for transmission according to said modes, and a carrier-dependent signal-to-noise ratio normalised for a unit transmission power.

6. A method according to claim 5, characterised in that the normalised transition costs are pre-stored in a first matrix, discarding transitions which would result in allocation of a worst value of said first parameter than attained by a lower cost transition.

7. A method according to claim 6, characterised in that the target modes of the transitions stored in said first matrix are stored in a second matrix, and, by using said first and second matrices, for each value normalised cost function a list is created of the indexes of the sub-carriers having said value of the normalised cost function.

8. A method of bit rate and power allocation to individual carriers of an OFDM communication system, each carrier conveying coded and modulated signals and modulation being an adaptive modulation, the method determining a maximum value for a total bit rate attainable for a budget power, characterised in that, for a system providing also for an adaptive coding, the method comprises the steps of:

a1) determining, for all carriers, a respective plurality of transmission modes characterised

each by a specific combination of a modulation format and a coding scheme and consequently by a specific combination of values of bit rate and transmit power;

b1) determining, for all carriers, bit-per-power transition costs associated with transitions from each mode to a lower one characterised by a lower bit rate and a lower power;

c1) allotting to each carrier a respective first transmission mode associated with a maximum value of information bits and a maximum power;

d1) evaluating the total transmit power required by said first transmission modes;

e1) if the total transmit power does not exceed a budget power, allotting said maximum number of information bits to all carriers;

f1) if the total transmit power exceeds a budget power, changing the mode allotted to one of the carriers from said first mode to a lower mode, the carrier and the target mode selected for such change being those for which said change involves the minimum bit-per-power transition cost;

g1) evaluating and the total number of information bits and the total transmit power after the mode change at step f1);

h1) iterating steps f1) and g1) until attaining a total transmit power not exceeding the budget power.

9. A method as claimed in claim 8, characterised in that the carriers are allotted the bit rates and powers determined at the end of the iterations.

10. A method as claimed in claim 8, characterised in that the carriers are allotted the bit rates and powers determined at the end of the iterations if the total power is equal to the budget power.

11. A method as claimed in claims 8 and 10, characterised in that, if the total power at the end of the iterations is lower than the budget power, the method comprises the further steps of:

i1) undoing the last mode change;

j1) checking whether in any of the carriers there are mode changes associated with higher transition costs but leading to a respective target mode associated with a higher bit rate;

k1) in the affirmative, returning to step f1);

l1) in the negative, using the transmission modes determined at step h1).

12. A method according to any of claims 8 to 11, characterised in that the optimum power determined for each carrier at the end of the iterations is normalised relative to the budget power, whereby transmission of a symbol takes place with said budget power.

13. A method of bit rate and power allocation to individual carriers of a multicarrier communication system, each carrier conveying coded and modulated signals and modulation being an adaptive modulation, the method determining, for a given total bit rate, a minimum transmit power and hence a maximum operating margin, characterised in that, for a system providing also for an adaptive coding, the method comprises the steps of:

a2) determining, for all carriers, a respective plurality of transmission modes characterised each by a specific combination of a modulation format and a coding scheme and consequently by a specific combination of values of bit rate and transmit power;

b2) determining, for all carriers, bit-per-power transition costs associated with transitions from each mode to a lower one characterised by a lower power and a lower bit rate;

c2) allotting to each carrier a respective first transmission mode associated with a maximum bit rate and a maximum power;

d2) evaluating the total bit rate required by said first transmission modes;

e2) if the total bit rate does not exceed the given bit rate, allotting said maximum bit rates and powers to all carriers;

f2) if the total bit rate exceeds the given bit rate, changing the mode allotted to one of the carriers from said first mode to a lower mode, the carrier and the target mode selected for such change being those for which said change involves the minimum transition cost;

g2) evaluating the total bit rate and the total transmit power after the mode change at step f2);

h2) iterating steps f2) and g2) until obtaining a total bit rate not exceeding the given bit rate.

14. A method as claimed in claim 13, characterised in that the carriers are allotted the bit rates and powers determined at the end of the iterations.

15. A method as claimed in claim 13, characterised in that the carriers are allotted the bit rates and powers determined at the end of the iterations if the total bit rate is equal to or is the closest approximation of the given bit rate.

16. A method as claimed in claims 8 and 10, characterised in that, if the total bit rate at the end of the iterations is lower than the given bit rate or a closest approximation of the given bit rate, the method comprises the further steps of:

i2) undoing the last mode change;

j2) checking whether in any of the carriers there are mode changes associated with higher transition costs but leading to a respective target mode associated with a higher bit rates;

k2) in the affirmative, returning to step f2);

l2) in the negative, using the transmission modes determined at step h2).

17. A multicarrier communication system comprising, at a transmitting end, means (5, 6) for coding and modulating a sequence of digital signals so as to obtain a sequence of symbols that are fed to means (7) for transmitting each symbol by using a plurality of suitably spaced carriers, the coding, modulating and transmitting means (5, 6, 7) being associated with a control unit (8) allocating transmission parameters to the individual carriers so as to determine an optimum overall value of a first of said transmission parameters while meeting predetermined constraints for an overall value of a second parameter, characterised in that said control unit (8) is arranged to allocate said parameters by using the method according to any of claims 1 to 7.

18. A communication system according to claim 17, wherein said carriers are orthogonally frequency division multiplexed carriers, and the control unit (8) allots bit rate and power to the carriers by using the method according to any of claims 8 to 16.